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Study of indoor radon and thoron progeny levels in surrounding areas of Nalbari, Assam, India

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Abstract : With the growing understanding of the role of radon and its daughter products as major sources of radiation exposure, the importance of large number of estimation of radon concentration in various parts of the country is realized. Inhalation of radon, thoron and their decay products is the major source of the total radioactive dose received by the human population from natural radiation. The indoor radon and thoron progeny levels in Nalbari area of Assam are studied by using the LR-115 (type II) Solid State Nuclear Track Detector in Plastic Twin Chamber dosimeter. Radon and thoron progeny levels in different types of dwellings for one full calendar year are presented in this paper. For Assam Type (A.T.) houses, indoor radon progeny concentrations vary from 0.17 to 0.64 mWL with an annual geometric mean of 0.27 mWL and that for Reinforced Cement Concrete (R.C.C.) houses vary from 0.22 mWL to 0.60 mWL with the annual geometric mean of 0.37 mWL. The thoron progeny levels in A.T. houses also vary from 0.01 to of 0.05 mWL with an annual geometric mean of 0.02 mWL and that for R.C.C. houses vary from 0.02 to 0.08 mWL with the annual geometric mean of 0.04 mWL.

Keywords : Radon progeny, thoron progeny, nuclear track detector, LR-115, etching.

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1. Introduction

Radon is constantly generated all over the earth due to the decay of radium present in crustal materials. The major motivation for initiating radon studies is to assess the risk to human population from indoor Rn^{222}. It is estimated that out of 98% of average radiation dose received by man from natural sources, about 52% is due to breathing of radon, thoron, and progeny present in the dwellings [1]. Available data for India has shown that

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60% of total radiation dose received by the population is due to inhalation of Rn^{222} progeny [2]. Radon enters into the closed environment of a dwelling as a result of emanations from radium-226 contained in the building materials, as well as by diffusion from the soil. The radon entry points for the pressure driven flow of Rn bearing soil gas depend on a number of factors, like the types of house substructures, construction practice used, the age and the structure integrity of the house [3]. In some places during cold seasons when windows are closed and heaters are on, the difference in temperature between the indoor air and the outdoor air causes a thermal stack effect. Warm air rises in a house and creates a region of low pressure in the lower portions of the building. Then lower level of the building, such as a basement, draws radon gas from the soil into the building.

In the present work an effort has been made to estimate indoor radon and thoron progeny levels in some places in and around Nalbari areas of Brahmaputra Valley in Assam by using State Nulcear Track Detector (SSNTD) in plastic twin-chamber dosimeter cups [4–6].

2. Experimental technique

In the present study, strippable cellulose nitrate film, LR-115 (type II) were exposed in three different modes : (1) Bare mode, (2) Cup with filter paper and (3) Cup with membrane. These three modes give the radon and thoron gas in Bq.m^{-3} and PAEC of individual progenies in terms of mWL units.

Three LR-115 (type II) detectors of size 3 cm × 3 cm were placed in proper positions of the dosimeter cups. The base detector, mounted on the outside of the cup, views a hemisphere of air of radius at least 9.1 cm, the range of ^{212}Po alpha in air or 6.4 cm, the range of ^{214}Po alpha [7]. It records all the tracks due to radon, thoron and their progenies. In the cup with filter paper mode, the detector was fixed on the dividing wall within the dosimeter cup and the mouth of the chamber on its side was covered with a filter paper. In the other chamber of the cup, the detector was fixed on the other side of the same wall and the mouth of the chamber of this end was covered with a filter paper, a mylar and then a filter paper. Membrane compartment does not permit the solid progeny of thoron to pass through them and partly reduces the rate of diffusion of thoron gas itself due to its short half-life. It has been estimated that 98% of radon penetrates, but thoron does not enter the cup [8].

The Twin-Chamber dosimeter cups with detectors were installed inside the rooms in the houses. The selected houses were single story both for Assam Type (A.T.) and Reinforced Cement Concrete (R.C.C.) houses. The detectors were installed in such a way that no wall or other surfaces (like ceiling and roof) is closer than 10 cm. The cups were exposed for 90–95 days after which they were retrieved. The choice of the house was random and one and only one room in each house was selected for the measurement.

The latent tracks registered on the detector can be enlarged to microscopically visible size by chemical etching. After retrieving, the detectors were etched in 2.5 N NaOH and etching was done at (60 ± 1) ^{o}C for 90 min. A magnetic stirrer with mild agitation is used throughout for uniform etching. The measurement of optically visible tracks is performed using an optical microscope under magnification of 200X. The recorded track density was then converted to progeny concentration in mWL by using appropriate calibration factors and mathematical relations [5].

3. Results and discussion

The results of the measured radon and thoron progeny levels in different types of dwellings for one full calendar year (2001-2002) taken over four quarters to study seasonal variations are shown respectively in Tables 1 and 2. It can be seen that the mean indoor radon progeny level varies from 0.17 to 0.64 mWL with an annual geometric mean of 0.27 mWL and that for Reinforced Cement Concrete (R.C.S.) houses varies from 0.22 to 0.60 mWL with the annual geometric mean of 0.37 mWL.

Table 1. Indoor radon progeny levels observed in different types of houses of Nalbari.

House Type	House No.	Radon progeny in mWL				
		Dec 2001-March 2002	March-June 2002	June-Sept 2002	Sept-Dec 2002	Mean
A.T.	1	024	0.23	0.21	0.24	0.23±0.001
	2	0.39	0.24	0.19	0.24	0.25±0.009
	3	0.27	0.23	0.20	0.25	0.24±0.003
	4	0.26	0.21	0.17	0.26	0.22±0.004
	5	0.50	0.26	0.23	0.50	0.35±0.015
	6	0.23	0.18	0.17	0.20	0.19±0.003
	7	0.31	0.20	0.17	0.22	0.22±0.006
	8	0.38	0.27	0.25	0.34	0.31±0.006
	9	0.40	0.26	0.25	0.37	0.31±0.008
	10	0.64	0.39	0.25	0.62	0.44±0.019
R.C.C.	1	0.53	0.36	0.31	0.38	0.39±0.009
	2	0.43	0.32	0.22	0.27	0.30±0.009
	3	0.50	0.31	0.27	0.32	0.34±0.10
	4	0.60	0.45	0.41	0.45	0.47±0.008
	5	0.44	0.38	0.31	0.38	0.37±0.005
	6	0.47	0.31	0.24	0.36	0.33±0.010
	7	0.56	0.41	0.38	0.43	0.44±0.008
	8	0.42	0.28	0.25	0.31	0.31±0.007
	9	0.52	0.30	0.25	0.33	0.34±0.012
	10	0.51	0.43	0.29	0.50	0.42±0.010

Table 2. Indoor thoron progeny levels observed in different types of houses of Nalbari.

House Type	House No.	Thoron progeny in mWL				
		Dec 2001-March 2002	March-June 2002	June-Sept 2002	Sept-Dec 2002	Mean
	1	0.04	0.02	0.01	0.02	0.02±0.001
	2	0.03	0.02	0.01	0.02	0.02±0.001
	3	0.04	0.02	0.01	0.03	0.02±0.001
	4	0.03	0.02	0.02	0.03	0.02±0.001
A.T.	5	0.03	0.02	0.01	0.03	0.02±0.001
	6	0.04	0.02	0.02	0.03	0.03±0.001
	7	0.04	0.02	0.01	0.01	0.02±0.001
	8	0.05	0.03	0.03	0.03	0.03±0.001
	9	0.05	0.03	0.02	0.04	0.03±0.001
	10	0.04	0.02	0.01	0.02	0.02±0.001
	1	0.05	0.03	0.03	0.04	0.04±0.001
	2	0.04	0.03	0.03	0.04	0.03±0.001
	3	0.05	0.03	0.02	0.03	0.03±0.001
	4	0.04	0.03	0.02	0.03	0.03±0.001
R.C.C.	5	0.08	0.03	0.02	0.04	0.04±0.003
	6	0.06	0.04	0.02	0.04	0.04±0.002
	7	0.06	0.05	0.03	0.05	0.05±0.001
	8	0.08	0.04	0.02	0.05	0.04±0.003
	9	0.05	0.03	0.02	0.03	0.03±0.001
	10	0.06	0.04	0.03	0.04	0.04±0.001

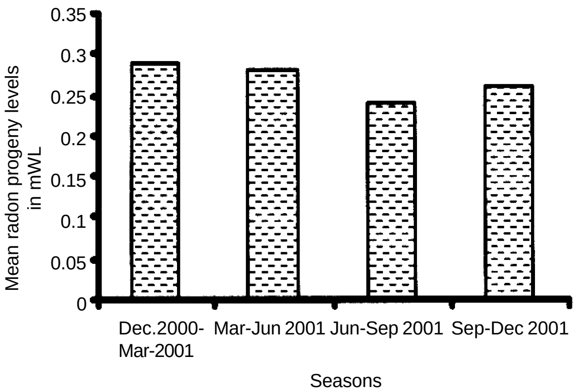

Figure 1(a) : Seasonal variation of radon progeny levels in A.T. houses of Nalbari.

The thoron progeny levels in Assam Type (A.T.) houses vary from 0.01 to 0.05 mWL with an annual geometric mean of 0.02 mWL and that for Reinforced Cement Concrete (R.C.C.) houses vary from 0.02 to 0.08 mWL with the annual geometric mean of 0.04 mWL. It is observed that for both radon and thoron progeny, higher levels are observed in R.C.C. houses. The possible reason could be due either to the nature of building materials used or the underlying soil/rock formation over which the building is located.

Figure 1(a) and Figure 1(b) show the seasonal variation of radon progeny concentrations in A.T. and R.C.C. houses, respectively. Similarly Figures 2(a) and 2(b) show the same seasonal variation of thoron progeny concentration in A.T. and R.C.C. houses, respectively.

A considerable variation in the indoor radon/thoron progeny concentration levels in different seasons is observed. From the Figures 1(a), 1(b), 2(a) and 2(b) it is observed that recorded mean radon and thoron progeny levels are maximum in the months from December 2001 to March 2002 *i.e.* in winter season. Poorer ventilation, due to closure of windows and doors for most part of the day during winter may be a possible cause of such increase of radon and thoron progeny levels. The ratios of radon and thoron progeny concentrations between winter and summer seasons vary from 1.1 to 2.6 and 1.3 to 4.0 respectively. There is not much difference of radon and thoron progeny levels between two seasons – March to June and June to September. Overlapping of these two seasons due to continued rainy climate, which is not very uncommon in Assam, may be the cause of such nearly constant radon and thoron progeny levels.

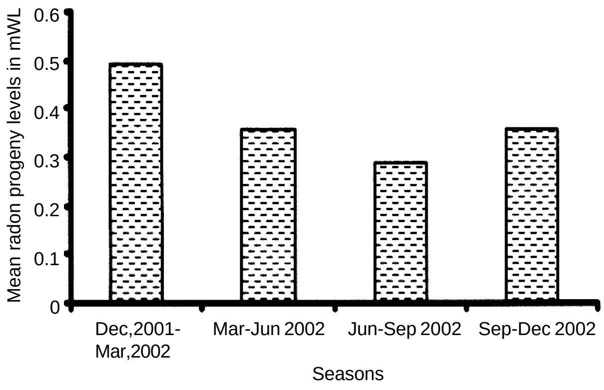

Figure 1(b). Seasonal variation of radon progeny levels in R.C.C. houses of Nalbari.

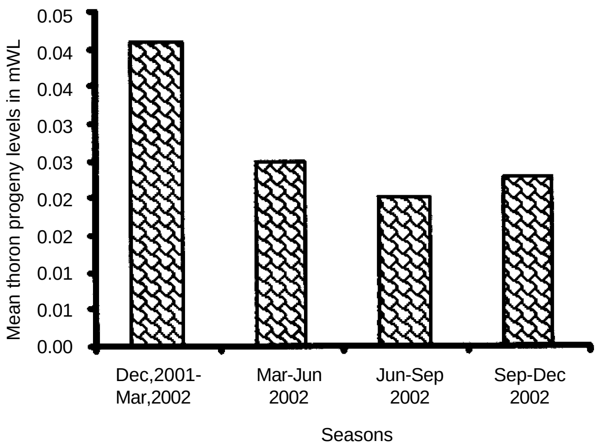

Figure 2(a). Seasonal variation of thoron progeny levels in A.T. houses of Nalbari.

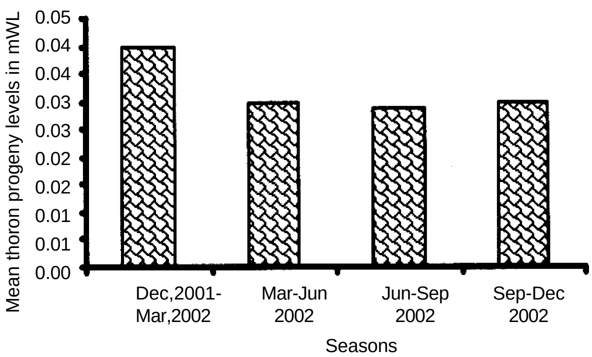

Figure 2(b). Seasonal variation of thoron progeny levels in R.C.C. houses of Nalbari.

Figures 3(a) and 3(b) show the comparison of radon and thoron progeny levels in different types of houses.

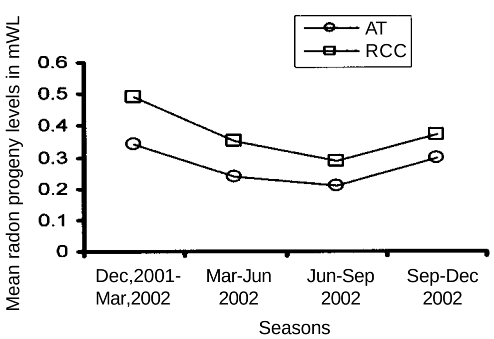

Figure 3(a). Comparison of radon progeny levels in two types of houses of Nalbari.

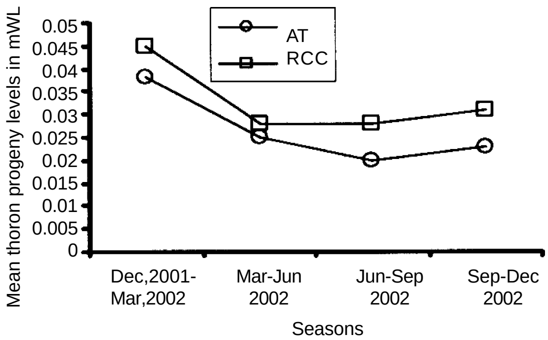

Figure 3(b). Comparison of thoron progeny levels in two types of houses of Nalbari.

4. Conclusion

In the present work higher values are found for dwellings having R.C.C. structure (ground floor). Thorough investigation of indoor radon levels and their dependence on building materials, radon content of soil and geology of the location will help in understanding causes of variation of radon and thoron progeny levels and recommending preventive measures.

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